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Kim

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(54) **LIGHT EMITTING DEVICE AND LIGHT EMITTING DEVICE PACKAGE**

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(51) **Int. Cl.**

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H01L 33/60	(2010.01)
H01L 23/00	(2006.01)
H01L 33/50	(2010.01)
H01L 33/56	(2010.01)

(52) **U.S. Cl.**

CPC ***H01L 33/60*** (2013.01); ***H01L 24/17*** (2013.01); ***H01L 33/501*** (2013.01); ***H01L 33/56*** (2013.01); *H01L 2224/16225* (2013.01); *H01L 2224/48091* (2013.01); *H01L 2224/73265* (2013.01); *H01L 2924/01322* (2013.01); *H01L 2924/12041* (2013.01); *H01L 2924/15787* (2013.01)

(58) **Field of Classification Search**

CPC H01L 2924/12041; H01L 2924/00; H01L 33/501; H01L 2224/48091; H01L 2924/00014; H01L 33/60; H01L 2224/73265; H01L 33/502; H01L 33/56; H01L 24/17; H01L 2224/16225

See application file for complete search history.

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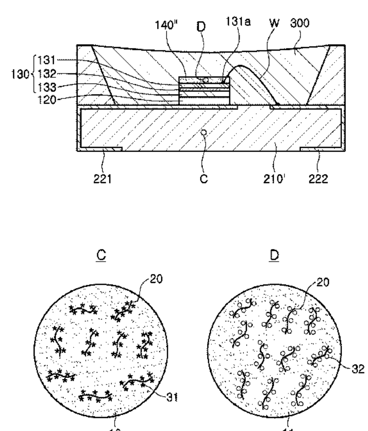
(57) **ABSTRACT**

According to example embodiments, a light emitting device package includes a package body including nanofibers and light-reflective particles dispersed in a resin, first and second electrodes in the package body, and a light emitting device on the package body. The emitting device is electrically connected to the first and second electrodes.

19 Claims, 12 Drawing Sheets



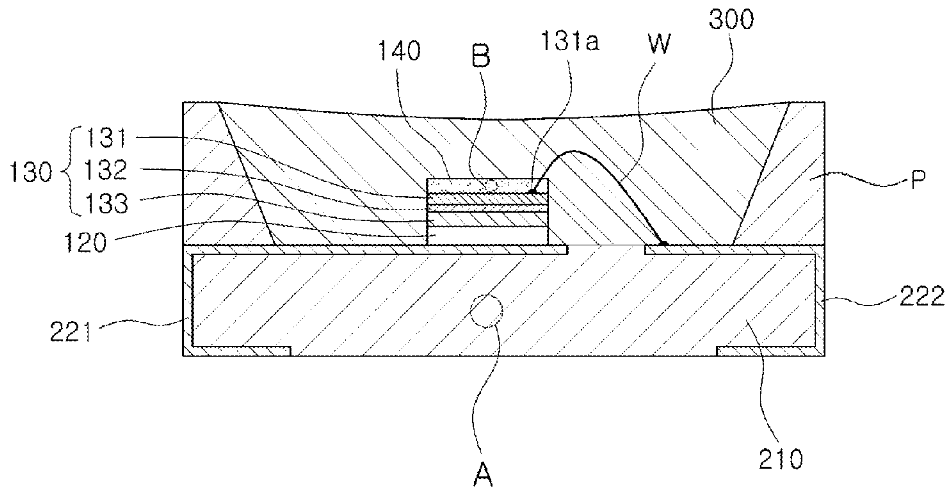


FIG. 1

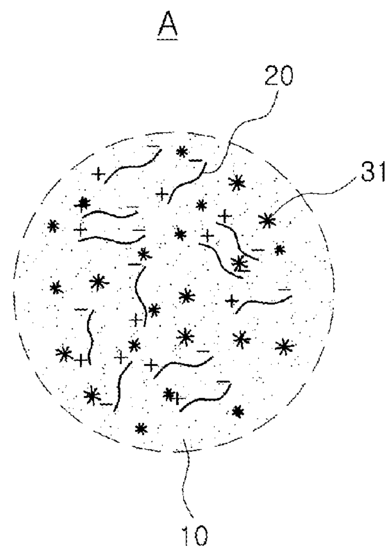


FIG. 2

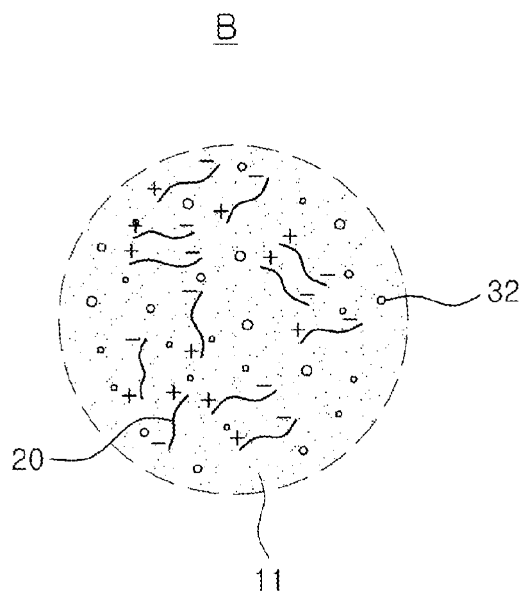

B
32
20
11

FIG. 3

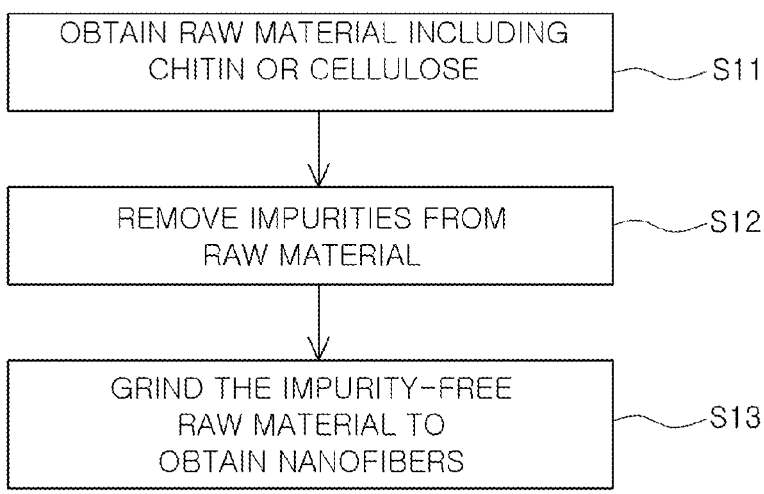

OBTAIN RAW MATERIAL INCLUDING CHITIN OR CELLULOSE
S11
REMOVE IMPURITIES FROM RAW MATERIAL
S12
GRIND THE IMPURITY-FREE RAW MATERIAL TO OBTAIN NANOFIBERS
S13

FIG. 4

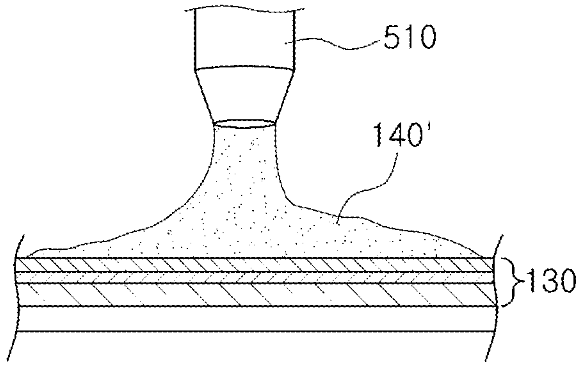


FIG. 5A

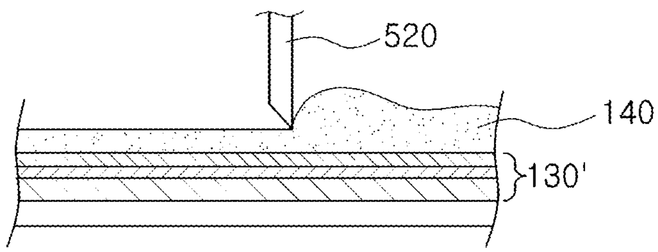


FIG. 5B

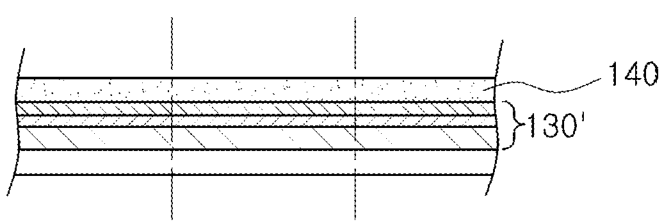


FIG. 5C

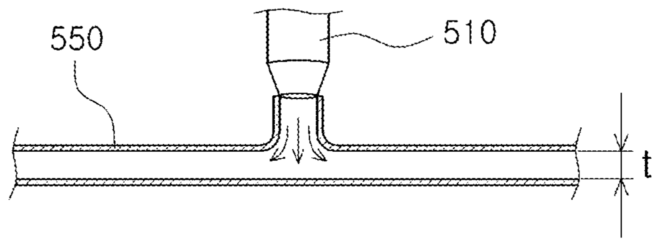


FIG. 6A

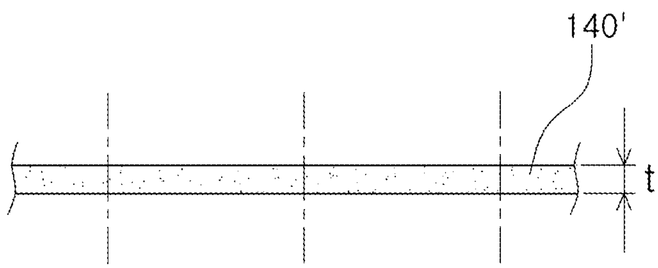


FIG. 6B

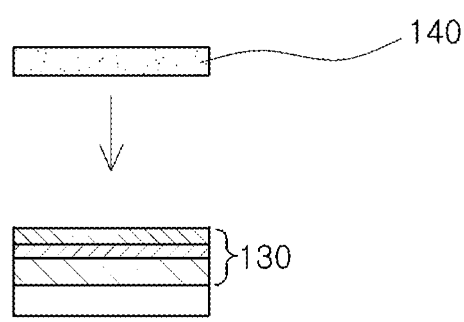


FIG. 6C

FIG. 7A

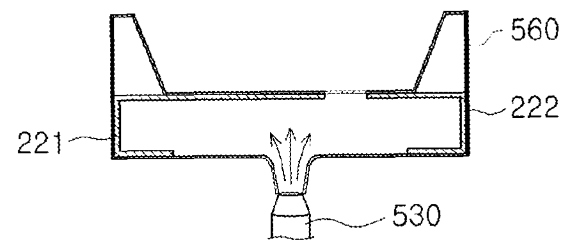


FIG. 7B

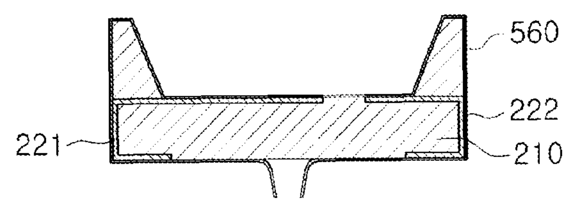


FIG. 7C

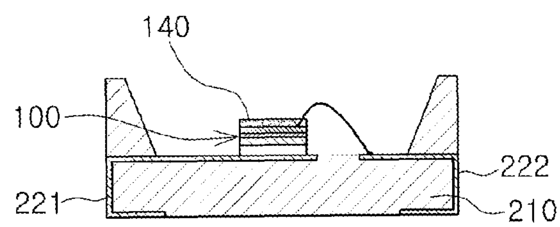
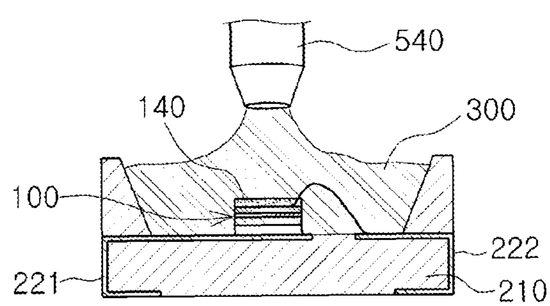


FIG. 7D



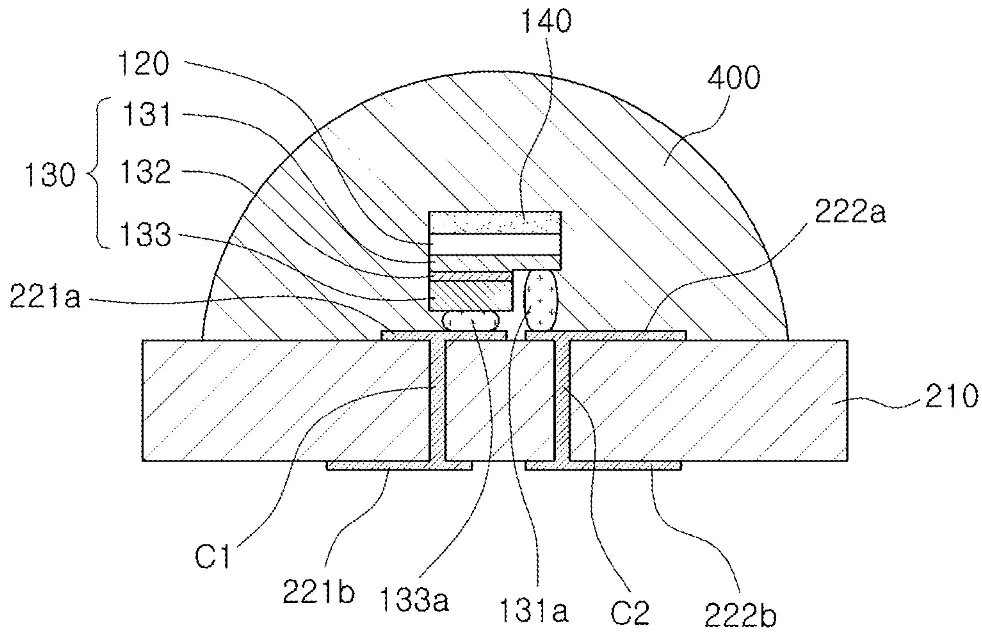

140
120
400
131
130
132
222a
133
221a
210
C1
221b
133a
131a
C2
222b

FIG. 8

FIG. 9A

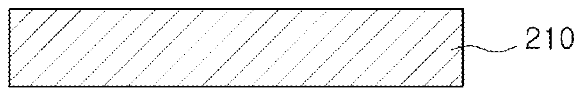


FIG. 9B

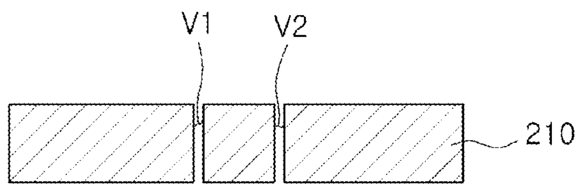


FIG. 9C

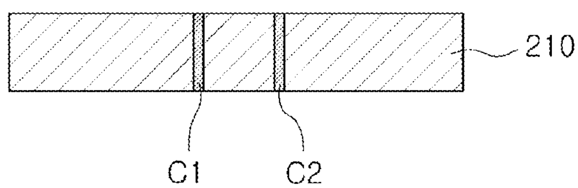


FIG. 9D

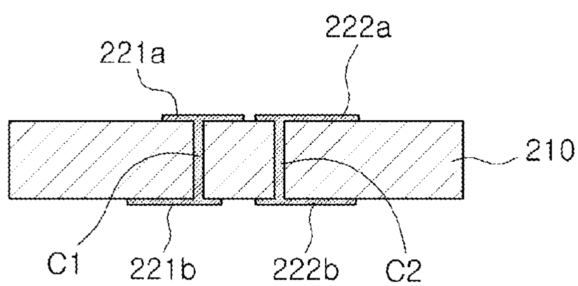
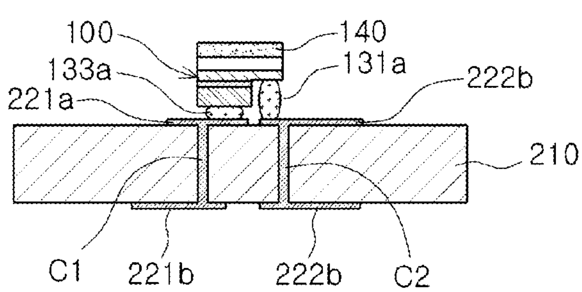


FIG. 9E



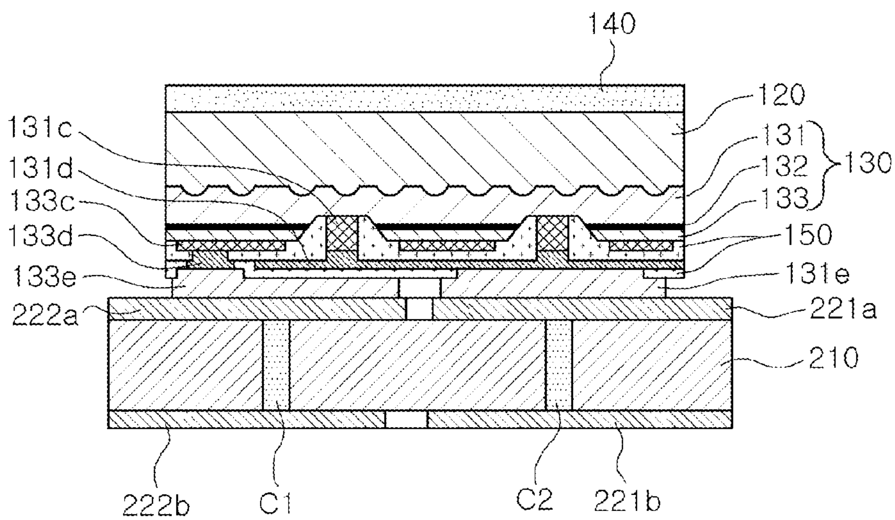

140
120
131
132
133
130
131c
131d
133c
133d
133e
150
131e
222a
221a
210
222b
C1
C2
221b

FIG. 10

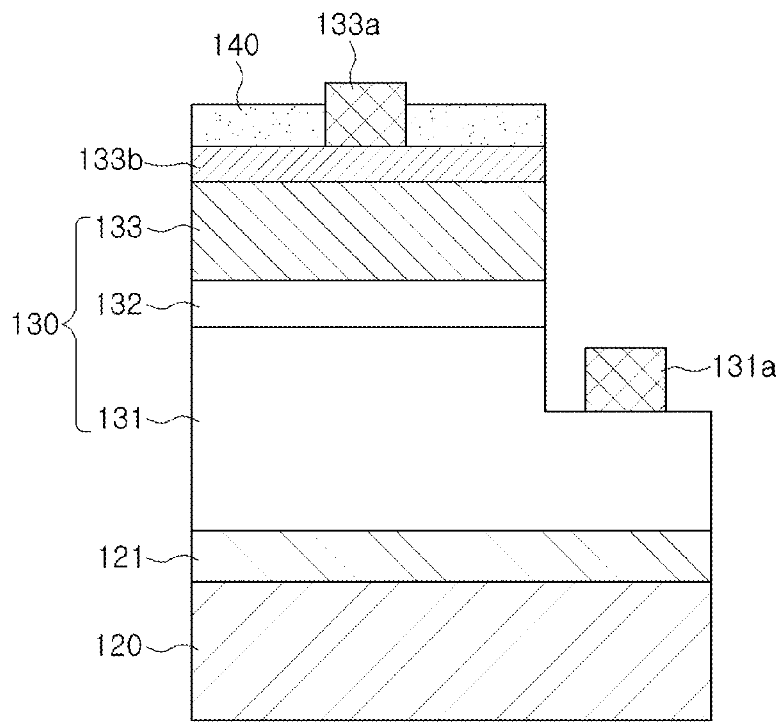

133a
140
133b
133
132
130
131
131a
121
120

FIG. 11

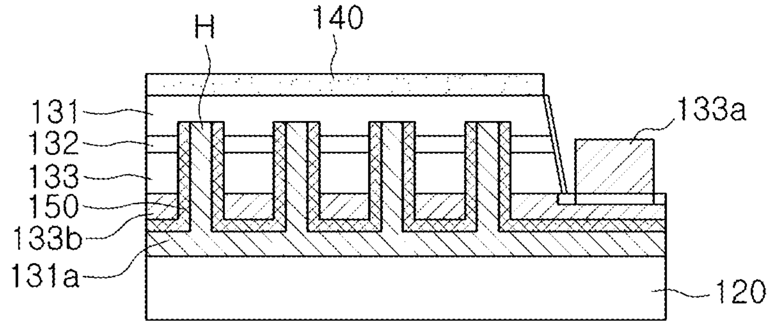

H
140
131
132
133
150
133b
131a
133a
120

FIG. 12

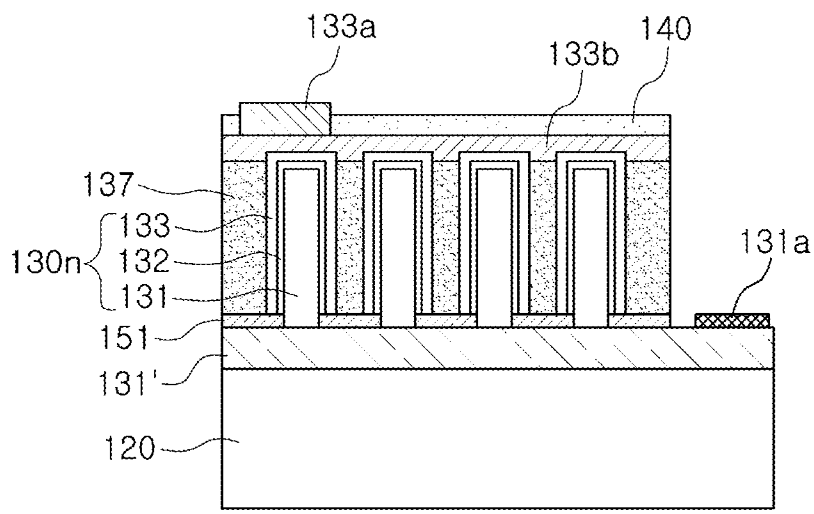

133a
133b
140
137
133
132
131
130n
151
131'
120
131a

FIG. 13

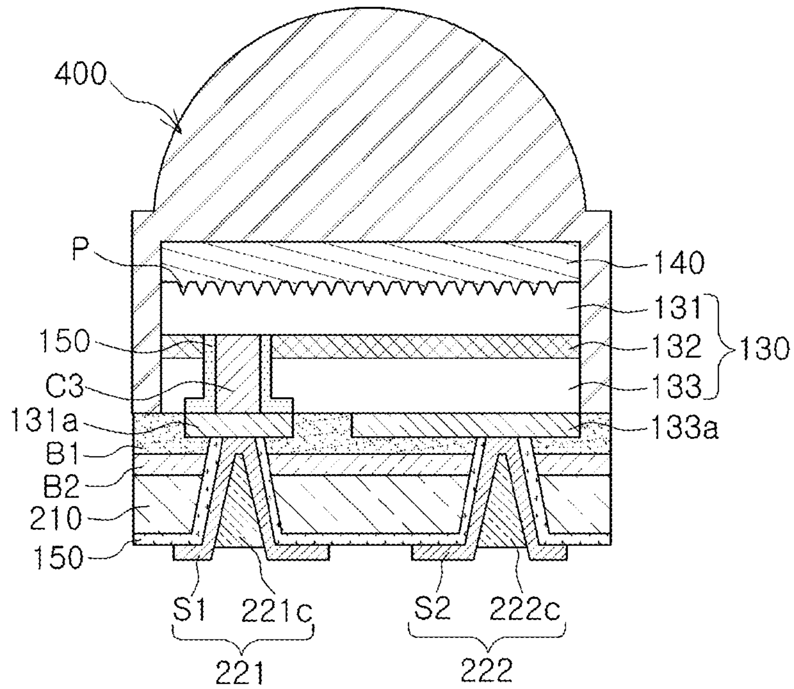

400
P
140
131
132
130
133
150
C3
131a
133a
B1
B2
210
150
S1
221c
S2
222c
221
222

FIG. 14

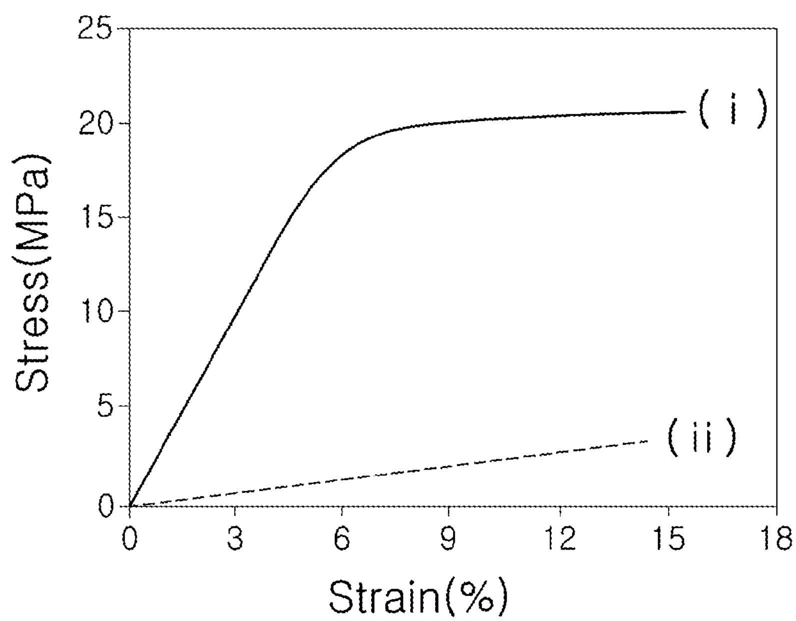

25
20
15
10
5
0
Stress(MPa)
(i)
(ii)
0
3
6
9
12
15
18
Strain(%)

FIG. 15

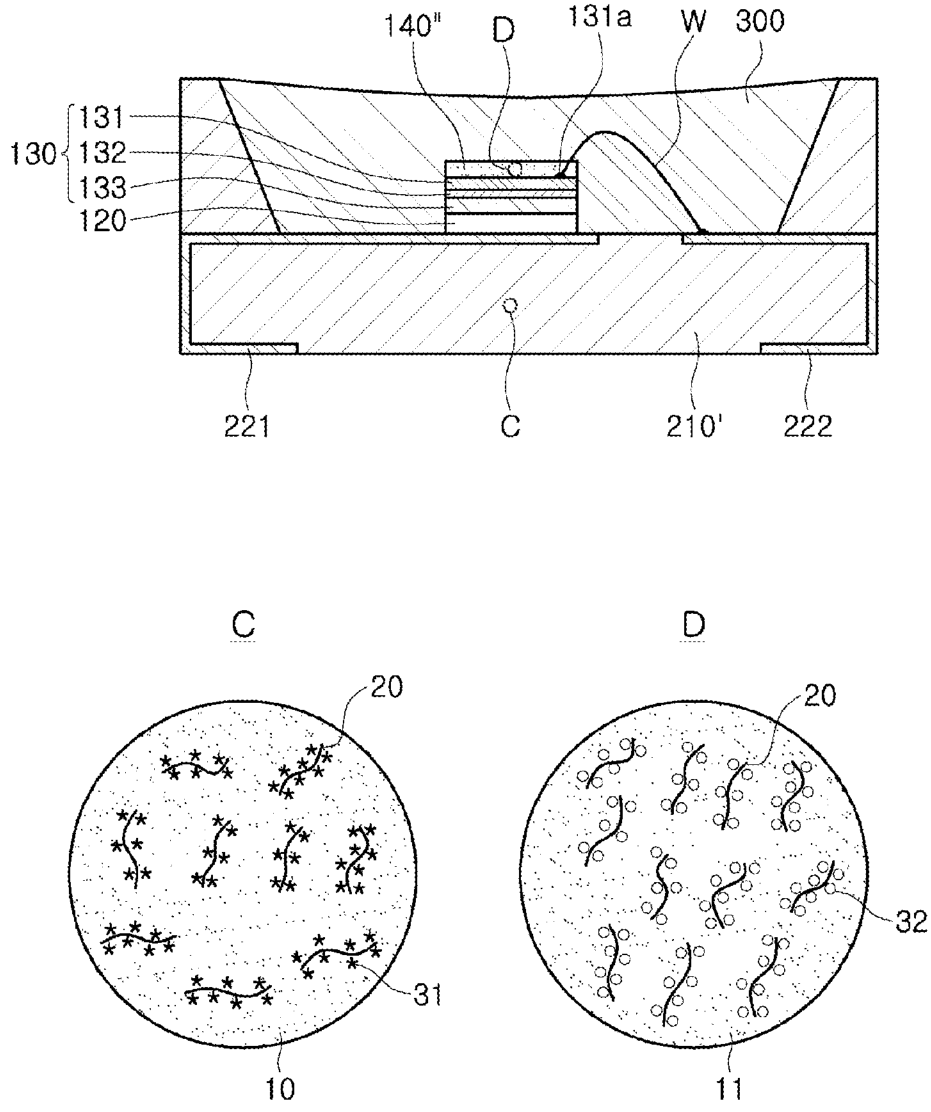

140"
D
131a
W
300
130
131
132
133
120
221
C
210'
222
C
D
20
20
32
31
10
11

FIG. 16

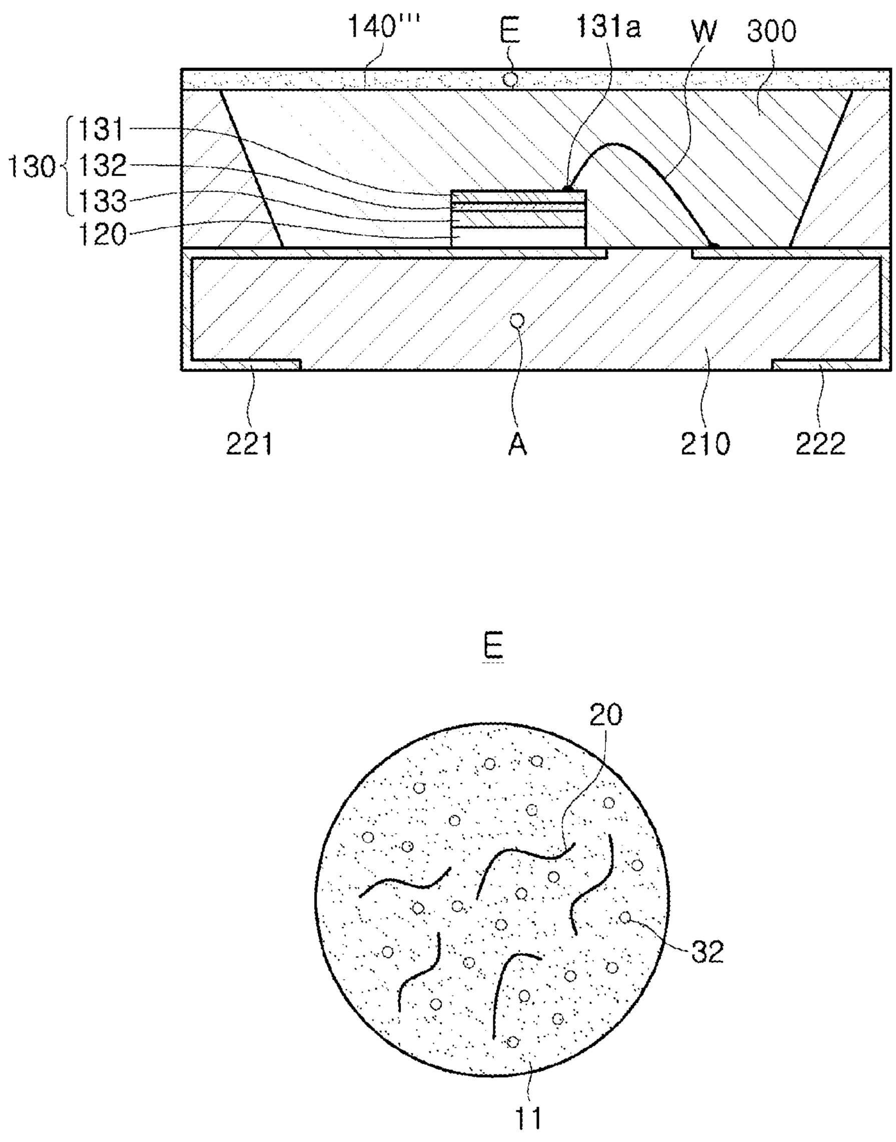


FIG. 17

LIGHT EMITTING DEVICE AND LIGHT EMITTING DEVICE PACKAGE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority under 35 U.S.C. §119 to Korean Patent Application No. 10-2013-0003265 filed on Jan. 11, 2013, in the Korean Intellectual Property Office, the entire disclosure of which is incorporated herein by reference.

BACKGROUND

1. Field

Example embodiments relate to a light emitting device package.

2. Description of the Related Art

In general, a semiconductor light emitting device may be provided in the form of a package including an electrode structure for applying driving power to the light emitting device, and in order to obtain desired color characteristics, a semiconductor light emitting device may have a wavelength conversion unit. Meanwhile, a semiconductor light emitting device, when driven, may emit a large amount of heat, so a difference in coefficients of thermal expansion between components included in the package may result in a defective package and a wavelength conversion unit may be damaged to degrade optical quality of light wavelengths converted thereby.

SUMMARY

Example embodiments relate to a light emitting device package in which a defect due to a difference between coefficients of thermal expansion may be reduced.

Example embodiments also relate to a light emitting device including a wavelength conversion unit in which a degradation of optical quality may be reduced.

According to example embodiments, a light emitting device package includes: a package body including a nanofibers and light-reflective particles dispersed in a resin; first and second electrodes in the package body; and a light emitting device on the package body. The light emitting device is electrically connected to the first and second electrodes.

In example embodiments, the resin may include one epoxy, silicone, modified silicone, a urethane resin, an oxetane resin, acryl, polycarbonate, polyimide, and any combination thereof.

In example embodiments, the nanofibers may include at least one of chitin and cellulose.

In example embodiments, a width of the nanofibers may be equal to or less than about 80 nm.

In example embodiments, a length of the nanofibers may be equal to or greater than about 1 μm.

In example embodiments, a weight ratio of the nanofibers to the resin may range from 1% to about 5%.

In example embodiments, a coefficient of thermal expansion of the package body may range from about 4 ppm/K to about 10 ppm/K at a temperature ranging from about 20° C. to about 150° C.

In example embodiments, a weight ratio of the light-reflective powder particles to the resin may range from about 20% to about 80%.

According to example embodiments, a light emitting device includes: a light emitting laminate including a first conductivity-type semiconductor layer, an active layer and a second conductivity-type semiconductor layer stacked on each other; and a wavelength conversion layer on the light emitting laminate. The wavelength conversion layer includes nanofibers and a wavelength conversion material dispersed in a light-transmissive resin.

In example embodiments, the nanofibers may include at least one of chitin and cellulose.

In example embodiments, a weight ratio of the nanofibers to the resin may range from 0.1% to less than 1%.

In example embodiments, one surface of the wavelength conversion layer may contact the light emitting laminate.

In example embodiments, the wavelength conversion layer may directly contact a light emitting surface of the light emitting laminate.

In example embodiments, a thickness of the wavelength conversion layer may range from about 20 μm to about 200 μm.

In example embodiments, a weight ratio of the wavelength conversion layer to the resin may range from about 50% to about 300%.

According to example embodiments, a light emitting device may include: a light emitting laminate and a wavelength conversion layer on the light emitting laminate. The wavelength conversion layer may include nanofibers and a wavelength conversion material dispersed in a light-transmissive resin.

In example embodiments, at least some of the nanofibers may be spaced part from at least some of the wavelength conversion material.

In example embodiments, a width of the nanofibers may be less than or equal to 80 nm, and the nanofibers may include at least one of chitin and cellulose.

According to example embodiments, a light emitting device package may include: a package body including fibers and light-reflective particles dispersed in a resin material; and the foregoing light-emitting device on the package body.

In example embodiments, the fibers may include at least one of chitin and cellulose, and a width of the fibers may be less than or equal to 80 nm.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features and other advantages of example embodiments will be more clearly understood from the following description on non-limiting embodiments taken in conjunction with the accompanying drawings, in which like reference characters to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead being placed up illustrating the principles of inventive concepts. In the drawings:

FIG. **1** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments;

FIG. **2** is a view illustrating materials used to form a package body of a light emitting device package according to example embodiments;

FIG. **3** is a view illustrating materials used to form a wavelength conversion layer of a light emitting device according to example embodiments;

FIG. **4** is a flow chart illustrating a method for manufacturing nanofibers to form a light emitting device package and a wavelength conversion layer according to example embodiments;

FIGS. **5**A through **6**C are cross-sectional views illustrating a method for manufacturing a light emitting device according to example embodiments;

FIGS. **7**A through **7**D are cross-sectional views illustrating a method for manufacturing a light emitting device package according to example embodiments;

FIG. **8** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments;

FIGS. **9**A through **9**E are cross-sectional views illustrating a method for manufacturing a light emitting device package according to example embodiments;

FIG. **10** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments;

FIGS. **11** through **13** are cross-sectional views illustrating a light emitting device installed in a light emitting device package according to example embodiments;

FIG. **14** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments;

FIG. **15** is a graph showing characteristics of a package body and a wavelength conversion layer according to example embodiments;

FIG. **16** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments; and

FIG. **17** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments.

DETAILED DESCRIPTION

Example embodiments will now be described more fully with reference to the accompanying drawings, in which some example embodiments are shown. Example embodiments, may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these example embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of example embodiments of inventive concepts to those of ordinary skill in the art. In the drawings, the thicknesses of layers and regions are exaggerated for clarity. Like reference numerals in the drawings denote like elements, and thus their description may be omitted.

It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or "directly coupled" to another element, there are no intervening elements present. As used herein the term "and/or" includes any and all combinations of one or more of the associated listed items. Other words used to describe the relationship between elements or layers should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," "on" versus "directly on").

It will be understood that, although the terms "first", "second", etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of example embodiments.

Spatially relative terms, such as "beneath," "below," "lower," "above," "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "includes" and/or "including," if used herein, specify the presence of stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or groups thereof. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

Example embodiments are described herein with reference to cross-sectional illustrations that are schematic illustrations of idealized embodiments (and intermediate structures) of example embodiments. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, example embodiments should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the actual shape of a region of a device and are not intended to limit the scope of example embodiments.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which example embodiments belong. It will be further understood that terms, such as those defined in commonly-used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

FIG. **1** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments.

Referring to FIG. **1**, a light emitting device package according to example embodiments may include a package body **210**, first and second electrode structures **221** and **222**, and a light emitting device electrically connected to the electrode structures **221** and **222**.

The package body **210** is provided to support the light emitting device and the first and second electrode structures **221** and **222**. The package body **210** according to example embodiments may include a resin as a basic material thereof and may include nanofibers and light-reflective powder particles dispersed in the resin.

The light emitting device may be a semiconductor light emitting device that emits light having a desired (or alternatively predetermined) wavelength due to an external electrical signal. For example, the light emitting device may include a light emitting laminate **130** including a first conductivity-type semiconductor layer **131**, a second conductivity-type semiconductor layer **133**, and an active layer **132** disposed therebetween.

In detail, the first conductivity-type semiconductor layer **131** and the second conductivity-type semiconductor layer **133** may be a p-type semiconductor layer and an n-type semiconductor layer, respectively, but example embodiments are not limited thereto and, conversely, the first conductivity-type semiconductor layer **131** and the second conductivity-type semiconductor layer **133** may be an n-type semiconductor layer and a p-type semiconductor layer, respectively. The first conductivity-type semiconductor layer **131** and the second conductivity-type semiconductor layer **133** may be nitride semiconductors. For example, the first and second conductive-type semiconductor layers **131** and **133** may be made of a material such as GaN, AlGaN, InGaN, AlGaInN, or the like, having an empirical formula $Al_xIn_yGa_{(1-x-y)}N$ (here, $0 \le x \le 1$, $0 \le y \le 1$, and $0 \le x+y \le 1$). The active layer **132** may be disposed between the first conductivity-type semiconductor layer **131** and the second conductivity-type semiconductor layer **133**, and may emit light having a desired (or alternatively predetermined) level of energy according to electron-hole recombination. The active layer **132** may have a multiple quantum well (MQW) structure in which quantum well layers and quantum barrier layers are alternately laminated. For example, an InGaN/GaN or GaN/AlGaN structure may be used.

As shown in FIG. **1**, according to example embodiments, the light emitting device may include the light emitting laminate **130** including the p-type semiconductor layer as a second conductivity-type semiconductor layer **133**, the active layer **132**, and the n-type semiconductor layer as a first conductivity-type semiconductor layer **131** sequentially disposed on the conductive substrate **120** and an electrode **131***a* formed on the n-type semiconductor layer **131**, but example embodiments are not limited thereto and the light emitting device may be variously modified as described hereinafter.

The first and second electrode structures **221** and **222** are provided to apply driving power to the light emitting device. The first and second electrode structures **221** and **222** are spaced apart from one another such that they are not electrically short-circuited, and may be configured to apply driving power to the first conductivity-type semiconductor layer **131** and the second conductivity-type semiconductor layer **133** of the light emitting device, respectively. Also, as illustrated in FIG. **1**, the first and second electrode structures **221** and **222** may extend from a region in which the first and second electrode structures **221** and **222** are electrically connected to the light emitting device, to a lower surface of the package body **210** and may be exposed from the lower surface of the package body **210**.

The light emitting device package may further include an encapsulation unit **300** protecting the light emitting device from external impacts and contamination. The encapsulation unit **300** may cover and encapsulate the light emitting device, and may be formed to have a desired (or alternatively predetermined) shape in an upper portion of the light emitting device and cured with a conductive wire W attached thereto. Here, the encapsulation unit **300** may be made of a resin having a high degree of transparency to allow light generated by the light emitting device to pass therethrough with minimum loss.

Also, as illustrated in FIG. **1**, the package body **210** may include a partition P surrounding the light emitting device, and in this case, light generated in the light emitting device and moving toward lateral surfaces thereof is reflected, enhancing luminance efficiency. The partition P may be made of the same materials as the package body **210**, and may be coated with a reflective material (e.g., metal) on a surface facing the light emitting laminate P. However, example embodiments are not limited thereto.

Meanwhile, when driven, the package body **210** may emit a large amount of heat due to energy that is not converted into optical energy. Energy may be converted to heat instead of optical energy due to a defect, or the like.

The converted thermal energy may be transmitted to the components, e.g., the first and second electrode structures **221** and **222**, the encapsulation unit **300**, and the package body **210** of the light emitting device package, as well as to the light emitting device, and if a difference between coefficients of thermal expansion of the components constituting the light emitting device package is significant, a defective package may be formed.

For example, coefficients of thermal expansion of the light emitting device may be approximately 6 ppm/K and the first and second electrode structures **221** and **222** may be approximately 16 ppm/K, or less at temperatures from 20° C. to 150° C. corresponding to a substantial operating temperature range of the light emitting device package, respectively, which are different from a coefficient of thermal expansion of a basic material, e.g., an epoxy resin (100 ppm/K) or a silicone resin (200 ppm/K), used to form the package body **210**, resulting in a defective package such as distortion of or cracks in the package body **210** or deformed or damaged electrode structures, or the like. In this connection, a method of mixing glass fibers in the resin has been proposed, but a coefficient of thermal expansion of the resin including glass fibers is tens of ppm/K, incapable of solving the problem of a defect due to a difference in coefficients of thermal expansion. Also, glass fibers, having a width ranging from 1 μm to 4 μm and a length ranging from 10 μm to 80 μm, may not be evenly dispersed in the resin and have inferior viscosity properties to cause the resin to agglomerate during a manufacturing process.

Thus, the package body **210** according to example embodiments includes nanofibers and light-reflective powder particles dispersed in the resin as a basic material. Materials constituting the package body **210** will be described in detail with reference to FIG. **2**.

FIG. **2** is a view illustrating materials used to form a package body of the light emitting device package according to example embodiments. Specifically, FIG. **2** is an enlarged view of region 'A' in FIG. **1**.

Referring to FIG. **2**, the package body **210** according to example embodiments may include a resin **10** as a basic material and nanofibers **20** and light-reflective powder particles **31** dispersed in the resin **10**.

The resin **10** may be a material selected from among epoxy, silicone, modified silicone, a urethane resin, an oxetane resin, acryl, polycarbonate, polyimide, and any combination thereof.

The nanofibers **20** may include at least one of chitin and cellulose and may have a shape of a fiber having a width equal to or less than 80 nm and a length equal to or greater than 1 μm. For example, the nanofibers **20** may have a shape having a width ranging from 10 nm to 20 nm and a length ranging from 1 μm to 2 μm, but example embodiments are not limited thereto. Chitin and cellulose may be obtained from a carapace of a crustacean or wood pulp, and when the nanofibers **20** are appropriately mixed in the resin **10**, the package body **210** may have a coefficient of thermal expansion similar to those of the other components included in the light emitting device package.

In detail, the nanofibers **20** may be dispersed to have the content ranging from 0.1% to 50% in the resin **10**, based on weight ratio of the nanofibers to the resin, and in this case, the package body **210** made of the resin **10** with the nanofibers **20** dispersed therein may have a linear coefficient of thermal expansion ranging from 1 ppm/K to 20 ppm/K, for example, ranging from 4 ppm/K to 10 ppm/K, at a temperature ranging from 20° C. to 150° C. Also, optical properties of the resin **10** with the nanofibers **20** dispersed therein may be controlled by regulating the weight ratio of the nanofibers **20**. For example, when the nanofibers **20** are dispersed in an amount of 0.1% to less than 1% in the resin **10**, the mixture material may have transparent optical properties. When the nanofibers **20** are contained in an amount of 1% or more, for example, in an amount of 1% to 5%, based on weight ratio of the nanofibers to the resin, the mixture material may have opaque optical properties.

In the application of the resin to the package body **210** according to example embodiments, the package body **210** may be formed to have reflection characteristics to induce light emitted from the light emitting device to travel in a desired direction. In this case, the nanofibers **20** may be dispersed and contained in the amount of 1% to 5% in the resin, and in order to reinforce the reflection characteristics, the package body **210** may further include the light-reflective powder particles **31** dispersed in the mixture.

The light-reflective powder particles **31** may be contained in an amount of ranging from 20% to 80% in the resin **10** to enhance reflection characteristics, and may include a metal oxide such as titanium oxide (TiO_2) or aluminum oxide (Al_2O_3), for example. In other words, a weight ratio of the light-reflective powder particles **31** to the resin may range from about 20% to about 80%.

According to example embodiments, differences in coefficients of thermal expansion between and among the components included in the light emitting device package may be reduced and, in particular, a defective package due to the differences in coefficients of thermal expansion commonly generated in the surfaces in which the package body **210** and the first and second electrode structures **221** and **222** are in contact or the surface in which the package body **210** and the light emitting device are in contact can be significantly improved.

In addition, due to chiral separation characteristics of the nanofibers **20**, opposite ends of the nanofibers **20** may be polarized, thus allowing the nanofibers **20** to be evenly dispersed in the resin **10**. Also, due to chiral separation characteristics of the nanofibers **20**, the viscosity of the resin **10** may be lowered, and thus, an agglomeration of the resin **10** during a process of forming the package body **210** can be effectively improved.

Hereinafter, the light emitting device having a wavelength conversion layer **140** according to example embodiments will be described in detail.

Referring back to FIG. **1**, the light emitting device according to example embodiments may include the light emitting laminate **130** and the wavelength conversion layer **140** formed on the light emitting laminate **130**.

The wavelength conversion layer **140** may be provided to obtain desired optical properties by converting a wavelength of light output from the light emitting laminate **130**. The wavelength conversion layer **140** may include a light-transmissive resin as a basic material and a wavelength conversion material dispersed in the light-transmissive resin. The wavelength conversion material **32** may include at least one of phosphors and quantum dots excited by light emitted from the light emitting laminate **130** to emit light having a different wavelength.

The wavelength conversion layer **140** may have a thickness ranging from about 20 μm to 200 μm, and may be disposed such that one surface thereof is in direct contact with the light emitting laminate **130**. In this case, the surface in which the wavelength conversion layer **140** and the light emitting laminate **130** are in direct contact may be a main light emitting surface of the light emitting laminate **130**, e.g., an upper surface of the light emitting laminate **130**. Namely, the wavelength conversion layer **140** may be provided as a thin film coated on or attached to the light emitting laminate **130**, and may include a wavelength conversion material **32** evenly distributed therein.

Meanwhile, the upper surface of the light emitting laminate **130** in contact with the wavelength conversion layer **140** may be a surface of the conductivity-type semiconductor layer or may be one surface of a light-transmissive substrate in a case in which the light emitting laminate further includes the light-transmissive substrate. For example, when a GaN semiconductor layer is used as the conductivity-type semiconductor layer, or when a sapphire substrate is used as the light-transmissive substrate, the upper surface of the light emitting laminate **130** may have a coefficient of thermal expansion of approximately 6 ppm/K in a temperature ranging from 20° C. to 150° C.

Meanwhile, coefficients of thermal expansion of a light-transmissive resin, e.g., an epoxy resin or a silicone resin, used to form the wavelength conversion layer **140** are 100 ppm/K and 200 ppm/K, respectively, which are different from the light emitting laminate **130** in a contact surface therebetween. Thus, when the light emitting device is driven, the wavelength conversion layer **140** may be damaged, such as being deformed, or the like, degrading optical properties.

In particular, in a case in which the wavelength conversion layer **140** is implemented as a thin film having a thickness ranging from 20 μm to 200 μm for the purpose of an even distribution of the wavelength conversion material, a problem of a defective light emitting device may be further aggravated due to discrepancy between the coefficients of thermal expansion.

Thus, the wavelength conversion layer **140** according to example embodiments may further include nanofibers dispersed in the light-transmissive resin as a basic material of the wavelength conversion layer **140**. This will be described in detail with reference to FIG. **3**.

FIG. **3** is a view illustrating materials used to form the wavelength conversion layer **140** of the light emitting device according to example embodiments. Specifically, FIG. **3** is an enlarged view of region 'B' in FIG. **1**.

Referring to FIG. **3**, the wavelength conversion layer **140** according to example embodiments includes a light-transmissive resin **11** as a basic material, and nanofibers **20** and a wavelength conversion material **32** dispersed in the light-transmissive resin **11**. As shown in FIG. **3**, at least some of the nanofibers **20** are spaced apart from at least some of the wavelength conversion material **32**.

The light-transmissive resin **11** may be a material selected from among epoxy, silicone, modified silicone, a urethane resin, an oxetane resin, acryl, polycarbonate, polyimide, and any combination thereof. The wavelength conversion material **32** may be contained in the amount of 50% to 300% in the light-transmissive resin **11**. In other words, a weight ratio of the wavelength conversion material **32** to the light-transmissive resin **11** may range from about 50% to about 300%. However, example embodiments are not limited thereto.

Like the package body **210**, the nanofibers **20** may include at least one of chitin and cellulose and may have a shape of fiber having a width equal to or less than 80 nm and a length equal to or greater than 1 μm and/or ranging from 1 μm to 2 μm. For example, the nanofibers **20** may have a width ranging from 10 nm to 20 nm. Since the width of the nanofibers **20** may be less than one-tenth of 300 nm to 800 nm as a wavelength range of visible light, light loss when the nanofibers **20** are mixed in the light-transmissive resin **11** can be reduced (and/or minimized).

The nanofibers **20** may be dispersed to have a content ranging from 0.1% to 1% in the light-transmissive resin **11**. In other words, a weight ratio of the nanofibers **20** to the resin **11** may range from 0.1% to less than 1%. In this case, the light-transmissive resin **11** with the nanofibers **20** dispersed therein may have light transmittance equal to or greater than 90% and a linear coefficient of thermal expansion ranging from 1 ppm/K to 20 ppm/K. For example, the light-transmissive resin **11** with the nanofibers **20** may have a linear coefficient of thermal expansion ranging from 4 ppm/K to 10 ppm/K, at a temperature ranging from 20° C. to 150° C. Namely, in a light emitting device according to example embodiments, since the difference in coefficients of thermal expansion in a surfaces of contact between the wavelength conversion layer **140** and the light emitting laminate **130** is significantly reduced, a problem of damage to the wavelength conversion layer **140** due to heat when the light emitting device is driven can be effectively improved.

Hereinafter, a method for obtaining the nanofibers **20** dispersed in the package body **210** and the wavelength conversion layer **140** and a method for manufacturing the light emitting device and the light emitting device package including the wavelength conversion layer **140** according to example embodiments will be described in detail.

FIG. **4** is a flow chart illustrating a method for obtaining the nanofibers **20** according to example embodiments.

Referring to FIG. **4**, a method for obtaining the nanofibers **20** according to example embodiments starts from operation S**11** of obtaining a raw material including chitin or cellulose. The raw material including chitin may be obtained from a carapace of a crustacean (e.g., a crab shell), and a raw material including cellulose may be obtained from a natural organic compound such as wood pulp, or the like.

Next, impurities in the raw material are removed (S**12**). During this process, impurities, e.g., proteins, salts, pigments, lipids, and the like, included in the raw material, are removed by applying an acid (HCl), a base (NaOH), and ethanol thereto.

Thereafter, the raw material without impurities is ground to obtain the nanofibers **20** (S**13**). In this process, the raw materials without impurities may be ground by using a grinder, or the like.

FIGS. **5**A through **6**C are cross-sectional views illustrating desired (or alternatively predetermined) of a method for manufacturing the light emitting device including the wavelength conversion layer **140** according to example embodiments.

First, referring to FIG. **5**A, a wavelength conversion layer **140'** may be coated on a light emitting laminate **130'** on the wafer level before being cut into individual device units, by using a dispenser **510**, or the like. In detail, at least one dispensing method including a pneumatic dispensing method, a mechanical dispensing method, and a jetting dispensing method able to be controlled to emit a small amount of the wavelength conversion layer **140'** may be used. Alternatively, a process such as screen printing, a spraying process, or the like, that may be comprehensively applied to a large amount of products may be used.

In the case of using the mechanical dispensing method, for example, as illustrated in FIG. **5**B, a squeegee **520** is pushed on a surface of the wavelength conversion layer **140'** from one end to the other end thereof to allow the wavelength conversion layer **140'** to have a uniform (or substantially uniform) thickness, and through a follow-up curing process, the wavelength conversion layer **140'** may be cured on the light emitting laminate **130'** on the wafer level. Thereafter, as illustrated in FIG. **5**C, the light emitting laminate **130'** on the wafer level with the wavelength conversion layer **140'** coated thereon may be cut into individual device units to manufacture a light emitting device according to example embodiments.

However, example embodiments are not limited thereto and the wavelength conversion layer **140** may be formed such that it is coated on the light emitting laminate **130** cut into individual device units. Also, unlike the method of coating the wavelength conversion layer **140** on the light emitting laminate **130**, a wavelength conversion layer **140** may be separately formed and may be subsequently attached to the light emitting laminate **130**.

In detail, referring to FIG. **6**A, the wavelength conversion layer **140'** may be injected into a rack **550** by using a dispenser **510** such that it has a desired thickness t. Thereafter, as illustrated in FIG. **6**B, the wavelength conversion layer **140'** injected into the rack **550** is cured, and when the curing process is completed, the rack **550** is removed and the wavelength conversion layer **140'** is cut into individual wavelength conversion layer units that may be attached to each light emitting laminate **130**. Thereafter, as illustrated in FIG. **6**C, the cut individual wavelength conversion layer **140** is attached to the light emitting laminate **130**, thus manufacturing a light emitting device.

Example embodiments are not limited to the foregoing manufacturing method and various modifications may be employed. For example, before being cut into individual units, the wavelength conversion layer **140'** may be first attached to the light emitting laminate **130'** on the wafer level and the light emitting laminate **130'** on the wafer level, with the wavelength conversion layer **140'** attached thereto, may be subsequently cut into individual light emitting device units. For example, electrophoresis or a conformal coating process may be used for local coating in a particular region such as an upper surface of the light emitting laminate.

FIGS. **7**A through **7**D are cross-sectional views illustrating desired (or alternatively predetermined) of a method for manufacturing a light emitting device package according to example embodiments.

Referring to FIG. **7**A, a material for forming the package body **210** is injected into the rack **560** in which the first and second electrode structures **221** and **222** are positioned, by using a dispenser **530**, or the like. The material for forming the package body **210** may be a mixture of the resin **10** as a basic material and the nanofibers **20** and the light-reflective powder particles **31** dispersed in the resin **10**. The rack **560** may be prepared to have a desired shape of the light emitting device package.

Meanwhile, unlike the case of using only the resin **10** as a material used to form the package body **210**, mixing of the nanofibers **20** having a width equal to or less than 80 nm and a length ranging from about 1 μm to 2 μm may lower viscosity due to the chiral separation characteristics of the nanofibers **20**. Namely, according to example embodiments, while the package body **210** is being formed, clumping or agglomeration of materials constituting the package body **210** within an inlet of the dispenser **530** or within the rack **560** can be effectively improved, and thus, the light emitting device package having a precisely formed structure can be manufactured.

Thereafter, as illustrated in FIG. **7**B, when the process of injecting the material for forming the package body **210** into the rack **560** is completed, the material is cured and, when the curing process is completed, the rack **560** is removed.

FIG. **7**C illustrates a state in which the light emitting device **100** is disposed on the package body **210** after the rack **560** is removed. The light emitting device **100** may be disposed to be contiguous with the first electrode structure **221** and wire-bonded to the second electrode structure **222**, thus receiving driving power from the first and second electrode structures **221** and **222**, but example embodiments are not limited thereto.

Thereafter, as illustrated in FIG. **7**D, the encapsulation unit **300** may be formed on the package body **210**. The encapsulation unit **300** may be coated on the package body **210** by using the dispenser **540** and subsequently cured so as to be completed.

FIG. **8** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments.

First, the light emitting device package includes the package body **210** having the resin **10** and the nanofibers **20** and the light-reflective powder particles **31** dispersed in the resin **10**, first and second electrode structures, and a light emitting device disposed on package body **210** and electrically connected to the first and second electrode structures.

The light emitting device is illustrated to have the wavelength conversion layer **140**, but it is not limited thereto. Namely, the light emitting device without the wavelength conversion layer **140** may also be provided.

Here, the first and second electrode structures may include conductive vias C**1** and C**2** and surface electrodes **221***a* and **222***a* and rear electrodes **221***b* and **222***b* formed on upper and lower surfaces of the package body **210** and electrically connected to conductive vias C**1** and C**2**.

The first and second electrode structures may be a made of a conductive material, e.g., a material selected from the group consisting of silver (Ag), aluminum (Al), titanium (Ti), tungsten (W), copper (Cu), tin (Sn), nickel (Ni), platinum (Pt), chromium (Cr), NiSn, TiW, AuSn, and a eutectic metal thereof, and in this case, a coefficient of thermal expansion thereof may have a value equal or less than approximately 16 ppm/K. Here, when the nanofibers **20** are contained in an amount of 1% to 50%, preferably, in an amount of about 1% to 5% in the resin **10**, as a basic material of the package body **210**, differences in the coefficients of thermal expansion between the package body **210** and other components, e.g., the light emitting device, the first and second electrode structures **221***a*, **222***a*, **221***b* and **222***b*, and the like, included in the light emitting device package are significantly reduced, and thus, a defective package problem due to heating when the light emitting device is driven can be effectively mitigated.

Also, the light emitting device package may include an encapsulation unit **400** formed on the package body **210**, and here, the encapsulation unit **400** may have a lens shape in order to control an angle of beam spread of light output from the light emitting device.

Meanwhile, as described above, the light emitting device may include the light emitting laminate **130** and the wavelength conversion layer **140** formed on the light emitting laminate **130**. The wavelength conversion layer **140** includes a light-transmissive resin **11** as a basic material, and the nanofibers **20** and the wavelength conversion material **32** dispersed in the resin **11**.

However, unlike FIG. **1**, in example embodiments, the light emitting laminate **130** includes an insulating substrate **120** and is mounted such that the first and second electrodes **131***a* and **133***a* formed on the first and second conductivity-type semiconductor layers **131** and **133** face downwardly. Here, a main light emitting surface of the light emitting laminate **130** is an upper surface of the insulating substrate **120**, and the wavelength conversion layer **140** is formed to be directly contiguous with the insulating substrate **120**.

In a case in which a sapphire substrate is employed as the insulating substrate **120**, a coefficient of thermal expansion of the insulating substrate **120** is approximately 6 ppm/K and that of the wavelength conversion layer **140** may range from 4 ppm/K to 10 ppm/K when the nanofibers **20** are contained in the amount of 0.1% to less than 1% in the light-transmissive resin **11** as a basic material of the wavelength conversion layer **140**. Thus, damage such as deformation of the wavelength conversion layer **140** due to heating of the light emitting device in an interface in which the light emitting laminate **130** and the wavelength conversion layer **140** are in contact can be significantly reduced.

Meanwhile, example embodiments are not limited thereto, and the insulating substrate **120** may be removed from the light emitting device and the wavelength conversion layer **140** may be formed to be in contact with the first conductivity-type semiconductor layer **131**. Here, the upper surface of the first conductivity-type semiconductor layer may have depressions and protrusions and, in this case, external quantum efficiency can be increased and a junction area of the first conductivity-type semiconductor layer **131** with respect to the wavelength conversion layer **140** can be increased, improving adhesive force.

Also, in FIG. **8**, the light emitting device is illustrated to be disposed on the light emitting device package including the package body **210** in which the nanofibers **20** are dispersed in the resin **10**, but example embodiments are not limited thereto and the light emitting device may be used in form of being directly mounted on a Printed Circuit Board (PCB) and it is obvious that the light emitting device is disposed on the package body **210** not containing the nanofibers **200** so as to be used.

FIGS. **9**A through **9**E are cross-sectional views illustrating a method for manufacturing a light emitting device package according to example embodiments.

Referring to FIG. **9**A, the package body **210** having the resin **10** and the nanofibers **20** and the light-reflective powder particles **31** dispersed in the resin **100**. Next, as illustrated in FIG. **9**B, through holes V**1** and V**2** may be formed to penetrate through the package body **210**. The through holes V**1** and V**2** are formed to form first and second conductive vias C**1** and C**2**, and here, at least a pair of through holes V**1** and V**2** may be formed. The through holes V**1** and V**2** may be formed by using an etching process using a mask.

Thereafter, referring to FIG. **9**C, the interiors of the through holes V**1** and V**2** are filled with a conductive material to form the first and second conductive vias C**1** and C**2**, and thus, an upper surface and a lower surface of the package body **210** may be electrically connected through the conductive vias C**1** and C**2**. The first and second conductive vias C**1** and C**2** may be formed through injection, spreading, plating, or the like.

Thereafter, as illustrated in FIG. **9**D, the first surface electrodes **221***a* and **222***a* and the first and second rear electrodes **221***b* and **222***b* are formed on the upper surface and the lower surface of the package body **210**, respectively. The surface electrodes **221**a and **222**a and the rear electrodes **221**b and **222**b may be electrically connected by the conductive vias C**1** and C**2**, and as illustrated in FIG. **9**E, the light emitting device **100** may be disposed on the first and second surface electrodes **221**a and **222**a. Here, the first and second electrodes **131**a and **133**a of the light emitting device **100** may be electrically connected to the first and second surface electrodes **221**a and **222**a, respectively. Thereafter, the encapsulation unit **400** is coated on the package body **210** to manufacture the light emitting device package as illustrated in FIG. **8**.

FIG. **10** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments.

Referring to FIG. **10**, a light emitting device according to example embodiments is mounted on a package body, which is configured to be different from the example as described above.

The light emitting device includes the light emitting laminate **130** disposed on one surface of the substrate **120** and first and second electrodes **131**c and **133**c disposed in the opposite side of the substrate **120** based on the light emitting laminate **130**. Also, the light emitting device includes an insulating layer **150** formed to cover the first and second electrodes **131**c and **133**c. The first and second electrodes **131**c and **133**c may be connected to first and second electrode pads **131**e and **133**e by the first and second electrical connection portions **131**d and **131**d, respectively.

Here, a wavelength conversion layer **140** is formed on an upper surface of the substrate **120** provided as a light emitting surface. The wavelength conversion layer **140** may include a light-transmissive resin as a basic material thereof and nanofibers and a wavelength conversion material dispersed therein.

The light emitting laminate **130** may include the first conductivity-type semiconductor layer **131**, the active layer **132**, and the second conductivity-type semiconductor layer **133** sequentially disposed on the substrate **120**. The first electrode **131**c may be provided as a conductive via connected to the first conductivity-type semiconductor layer **131** through the second conductivity-type semiconductor layer **133** and the active layer **132**. The second electrode **133**C may be connected to the second conductivity-type semiconductor layer **133**.

The insulating layer **150** has an open area exposing at least portions of the first and second electrodes **131**c and **133**c, and the first and second electrode pads **131**e and **133**e may be connected to the first and second electrodes **131**c and **133**c.

The first and second electrodes **131**c and **133**c may have a multilayer structure in which one or a plurality of layers made of a conductive material having ohmic characteristics with respect to the first conductivity-type semiconductor layers **131** and **133**, respectively, are formed. For example, the first and second electrodes **131**c and **133**c may be formed by depositing or sputtering one or more of silver (Ag), aluminum (Al), nickel (Ni), chromium (Cr), a transparent conductive oxide (TCO), and the like. The first and second electrodes **131**c and **133**c may be disposed in the same direction and may be mounted as a so-called flip-chip on a lead frame as described hereinafter. In this case, the first and second electrodes **131**c and **133**c may be disposed to face in the same direction.

In particular, the first electrical connection portion **131**d may be formed on the first electrode **131**c having a conductive via connected to the first conductivity-type semiconductor layer **131** by passing through the second conductivity-type semiconductor layer **133** and the active layer **132** within the light emitting laminate **130**.

The amount, a shape, a pitch, a contact area with the first conductivity-type semiconductor layer **131**, and the like, of the conductive via and the first electrical connection portion **131**d may be appropriately regulated in order to lower contact resistance, and the conductive via and the first electrical connection portion **131**d may be arranged in a row and in a column to improve current flow.

Another electrode structure may include the second electrode **133**c directly formed on the second conductivity-type semiconductor layer **133** and the second electrical connection portion **133**d formed on the second electrode **133**c. In addition to having a function of forming an electrical-ohmic connection with the second conductivity-type semiconductor layer **133**, the second electrode **133**c may be made of a light reflective material, whereby, as illustrated in FIG. **10**, in a state in which the light emitting device is mounted as a so-called flip chip structure, light emitted from the active layer **132** can be effectively emitted in a direction of the substrate **120**. Of course, the second electrode **133**c may be made of a light-transmissive conductive material such as a transparent conductive oxide, according to a main light emitting direction.

The two electrode structures as described above may be electrically separated by the insulating layer **150**. The insulating layer **150** may be made of any material as long as it has electrically insulating properties. Namely, the insulating layer **150** may be made of any material having electrically insulating properties, and here, preferably, a material having a low degree of light absorption is used. For example, a silicon oxide or a silicon nitride such as SiO_2, SiO_xN_y, Si_xN_y, or the like, may be used. If necessary, a light reflective filler may be dispersed in the light-transmissive material to form a light reflective structure.

The first and second electrode pads **131**e and **133**e may be connected to the first and second electrical connection portions **131**d and **133**d to serve as external terminals of the light emitting device, respectively. For example, the first and second electrode pads **131**e and **133**e may be made of gold (Au), silver (Ag), aluminum (Al), titanium (Ti), tungsten (W), copper (Cu), tin (Sn), nickel (Ni), platinum (Pt), chromium (Cr), NiSn, TiW, AuSn, or a eutectic metal thereof. In this case, when the light emitting device is mounted on the mounting substrate **120**, the light emitting device may be bonded by using a eutectic metal, so solder bumps generally required for flip chip bonding may not be used. The use of a eutectic metal advantageously obtains superior heat dissipation effects in the mounting method to the case of using solder bumps. In this case, in order to obtain excellent heat dissipation effects, the first and second electrode pads **131**e and **133**e may be formed to occupy a relatively large area.

Also, a buffer layer may be formed between the light emitting structure **130** and the substrate **120**. The buffer layer may be employed as an undoped semiconductor layer made of a nitride, or the like, to alleviate lattice defects in the light emitting structure grown thereon.

In example embodiments, the substrate **120** may have first and second main surfaces opposing one another, and an unevenness structure (i.e., a pattern of depressions and protrusions) may be formed on at least one of the first and second main surfaces. The unevenness structure formed on one surface of the substrate **120** may be formed by etching a portion of the substrate **120** so as to be made of the same material as that of the substrate. Alternatively, the unevenness structure may be made of a heterogeneous material different from that of the substrate **120**.

In example embodiments, since the unevenness structure is formed on the interface between the substrate **120** and the first conductivity-type semiconductor layer **131**, light emitted from the active layer **132** can be emitted on a variety of paths, and thus, a light absorption ratio of light absorbed within the semiconductor layer can be reduced and a light scattering ratio can be increased, increasing light extraction efficiency.

In detail, the unevenness structure may be formed to have a regular or irregular shape. The heterogeneous material used to form the unevenness structure may be a transparent conductor, a transparent insulator, or a material having excellent reflectivity. Here, as the transparent insulator, a material such as SiO_2, SiNx, Al_2O_3, HfO, TiO_2, or ZrO may be used. As the transparent conductor, a transparent conductive oxide (TCO) such as ZnO, an indium oxide containing an additive (e.g., Mg, Ag, Zn, Sc, Hf, Zr, Te, Se, Ta, W, Nb, Cu, Si, Ni, Co, Mo, Cr, or Sn), or the like, may be used. As the reflective material, silver (Ag), aluminum (Al), or a distributed Bragg reflector (DBR) including multiple layers having different refractive indices, may be used. However, example embodiments are not limited thereto.

Meanwhile, the substrate **120** may be removed from the first conductivity-type semiconductor layer **131**. To remove the substrate **120**, a laser lift-off (LLO) process using a laser, an etching or a polishing process may be used. Also, after the substrate **120** is removed, depressions and protrusions may be formed on the surface of the first conductivity-type semiconductor layer **131**.

As illustrated in FIG. **10**, the light emitting device may be mounted on the package body **210**. The package body **210** includes the surface electrodes **221***a* and **222***a* and the rear electrodes **221***b* and **222***b* formed on the upper and lower surfaces thereof, and the conductive vias C**1** and C**2** connecting the surface electrodes **221***a* and **222***a* and the rear electrodes **221***b* and **222***b*. The package body **120** may include a resin as a basic material and include nanofibers and light-reflective powder particles dispersed in the resin.

Hereinafter, various modifications of the light emitting device installed in a light emitting device package according to example embodiments are described.

FIGS. **11** through **13** are cross-sectional views illustrating a light emitting device installed in a light emitting device package according to example embodiments;

First, referring to FIG. **11**, the light emitting device employed in a semiconductor light emitting device package according to example embodiments includes the substrate **120** and the light emitting laminate **130** formed on the substrate **120**.

As the substrate **120**, an insulating substrate, a conductive substrate, or a semiconductor substrate may be used. For example, the substrate **120** may be made of sapphire, SiC, Si, $MgAl_2O_4$, MgO, $LiAlO_2$, $LiGaO_2$, GaN, AlN, AlGaN. For epitaxial growth of a GaN material, a GaN substrate as a homogeneous substrate may be desirable but it is difficult to manufacture a GaN substrate, incurring high production costs. Among them, a sapphire substrate, a silicon carbide (SiC) substrate, or the like, is commonly used as a heterogeneous substrate, and a sapphire substrate is more commonly utilized, relative to a costly silicon carbide substrate. In the case of a sapphire substrate, sapphire is a crystal having Hexa-Rhombo R3c symmetry, of which lattice constants in c-axis and a-axis directions are approximately 13.001 Å and 4.758 Å, respectively, and has a C-plane (0001), an A-plane (1120), an R-plane (1102), and the like. In this case, a nitride thin film may be relatively easily grown on the C-plane of the sapphire crystal, and because sapphire crystal is stable at high temperatures, the sapphire substrate is commonly used as a nitride growth substrate.

A silicon (Si) substrate may also be used. Since a silicon (Si) substrate is more appropriate for increasing a diameter and is relatively low in price, it may be used to facilitate mass-production. A technique of inducing a difference in lattice constants between the silicon substrate having (111) plane as a substrate surface and GaN to a 17% degree to thereby suppress the generation of crystal defects due to the difference between the lattice constants is required. Also, a difference in coefficients of thermal expansion between silicon and GaN is approximately 56%, requiring a technique of suppressing bowing of a wafer generated due to the difference in the coefficients of thermal expansion. Bowed wafers may result in cracks in the GaN thin film and make it difficult to control processes to increase dispersion of emission wavelengths of light in the same wafer, or the like. The silicon substrate absorbs light generated in the GaN-based semiconductor, lowering external quantum yield of the light emitting device. Thus, the substrate may be removed and a support substrate such as a silicon substrate, a germanium substrate, an SiAl substrate, a ceramic substrate, a metal substrate, or the like, including a reflective layer may be additionally formed to be used, as necessary.

Meanwhile, in case of using a heterogeneous substrate, defects such as dislocation due to a difference in lattice constants between a substrate material and a thin film material. Also, a difference in coefficients of thermal expansion between the substrate material and the thin film material causes bowing of the substrate when a temperature is changed, and bowing in the substrate causes cracks in the thin film. These problems may be reduced by using a buffer layer **121** formed between the substrate **120** and the GaN-based light emitting laminate **130**.

Thus, the light emitting device according to example embodiments further includes the buffer layer **121** formed between the substrate **120** and the light emitting laminate **130**. The buffer layer **121** may serve to adjust a degree of bowing of the substrate when an active layer is grown, to reduce wavelength distribution of a wafer.

Although differs according to a substrate type, the buffer layer **121** may be made of $Al_xIn_yGa_{1-x-y}N$ ($0 \le x \le 1$, $0 \le y \le 1$), in particular, GaN, AlN, AlGaN, InGaN, or InGaAlN, and a material such as ZrB_2, HfB_2, ZrN, HfN, TiN, or the like, may also be used as necessary. Also, the buffer layer **121** may be formed by combining a plurality of layers or by gradually changing a composition.

Meanwhile, a silicon (Si) substrate has a coefficient of thermal expansion significantly different from that of GaN. Thus, in case of growing a GaN-based thin film on the silicon substrate, when a GaN thin film is grown at a high temperature and is subsequently cooled to room temperature, tensile stress is applied to the GaN thin film due to the difference in the coefficients of thermal expansion between the silicon substrate and the GaN thin film, generating cracks. In this case, in order to limit (and/or prevent) the generation of cracks, a method of growing the GaN thin film such that compressive stress is applied to the GaN thin film while the GaN thin film is being grown is used to compensate for tensile stress. Also, a difference in the lattice constants between silicon (Si) and GaN involves a high possibility of a defect being generated therein. In the case of a silicon substrate, a buffer layer having a composite structure may be used in order to control stress for restraining warpage (or bowing) as well as controlling a defect.

For example, first, an AlN layer is formed on the substrate **120**. In this case, a material not including gallium (Ga) may be used in order to limit (and/or prevent) a reaction between silicon (Si) and gallium (Ga). The AlN layer is grown at a temperature ranging from 400° C. to 1,300° C. by using an aluminum (Al) source and a nitrogen (N) source. In this case, an AlGaN intermediate layer may be inserted into the center of GaN between the plurality of AlN layers to control stress, as necessary, thus forming a buffer layer having a composite structure.

Meanwhile, the substrate **120** may be completely or partially removed or patterned during a chip fabrication process in order to enhance light or electrical characteristics of the LED chip before or after the LED structure is grown. For example, in the case of a sapphire substrate, the substrate may be separated by irradiating a laser on an interface between the substrate and a semiconductor layer through the substrate, and in case of a silicon substrate or a silicon carbide substrate, the substrate may be removed through a method of polishing/etching, or the like.

Also, in removing the substrate, a different support substrate may be used, and in this case, the support substrate may be attached to the opposite side of the original growth substrate by using a reflective metal or a reflective structure may be inserted into a middle portion of a bonding layer to enhance light efficiency of the LED chip.

Referring to substrate patterning, an uneven surface or a sloped surface may be formed on a main surface (one surface or both surfaces) or a lateral surface of the substrate to enhance light extraction efficiency. A size of the pattern may be selected from within the range of 5 nm to 500 μm, and any pattern may be employed as long as it can enhance light extraction efficiency as a regular or an irregular pattern. The pattern may have various shapes such as a columnar shape, a peaked shape, a hemispherical shape, a polygonal shape, and the like.

The light emitting laminate **130** includes the first and second conductivity-type semiconductor layers **131** and **133** and the active layer **132** interposed therebetween. The first and second conductivity-type semiconductor layers **131** and **133** may have a unilayer structure, or, alternatively, the first and second conductivity-type semiconductor layers **131** and **133** may have a multilayer structure including layers having different compositions, thicknesses, and the like, as necessary. For example, the first and second conductivity-type semiconductor layers **131** and **133** may have a carrier injection layer for improving electron and hole injection efficiency, or may have various types of superlattice structure, respectively.

The first conductivity-type semiconductor layer **131** may further include a current diffusion layer in a region adjacent to the active layer **132**. The current diffusion layer may have a structure in which a plurality of $In_xAl_yGa_{(1-x-y)}N$ layers having different compositions or different impurity contents are iteratively laminated or may have an insulating material layer partially formed therein.

The second conductivity-type semiconductor layer **133** may further include an electron blocking layer in a region adjacent to the active layer **132**. The electron blocking layer may have a structure in which a plurality of $In_xAl_yGa_{(1-x-y)}N$ layers having different compositions are laminated or may have one or more layers including $Al_yGa_{(1-y)}N$. The electron blocking layer has a bandgap wider than that of the active layer **132**, thus limiting (and/or preventing) electrons from being transferred over the second conductivity-type (e.g., p-type) semiconductor layer **133**.

The light emitting laminate **130** may be formed by using metal-organic chemical vapor deposition (MOCVD). In order to fabricate the light emitting laminate S, an organic metal compound gas (e.g., trimethyl gallium (TMG), trimethyl aluminum (TMA)) and a nitrogen-containing gas (ammonia (NH_3), or the like) are supplied to a reaction container in which the substrate **1401** is installed as reactive gases, the substrate is maintained at a high temperature ranging from 900° C. to 1,100° C., and while a gallium nitride-based compound semiconductor is being grown, an impurity gas is supplied to laminate the gallium nitride-based compound semiconductor as an undoped n-type or p-type semiconductor. The n-type impurity may be silicon (Si), but example embodiments are not limited thereto. The p-type impurity may include at least one of zinc (Zn), cadmium (Cd), beryllium (Be), magnesium (Mg), calcium (Ca), barium (Ba), and the like. Among them, magnesium (Mg) and zinc (Zn) may be more commonly used.

Also, the active layer **132** disposed between the first and second conductivity-type semiconductor layers **131** and **133** may have a multi-quantum well (MQW) structure in which a quantum well layer and a quantum barrier layer are alternately laminated. For example, in the case of a nitride semiconductor, a GaN/InGaN structure may be used, or a single quantum well (SQW) structure may also be used.

In example embodiments, an ohmic-contact layer **133***b* may be formed on the second conductivity-type semiconductor layer **133**. The ohmic-contact layer **133***b* may have a relatively high impurity concentration to have low ohmic-contact resistance to lower an operating voltage of the element and enhance element characteristics. The ohmic-contact layer **133***b* may be formed of a GaN layer, a InGaN layer, a ZnO layer, or a graphene layer.

The first or second electrodes **131***a* and **133***a* electrically connected to the first and second conductivity-type semiconductor layers **131** and **133**, respectively, may be made of a material such as silver (Ag), nickel (Ni), aluminum (Al), rhodium (Rh), palladium (Pd), iridium (Ir), ruthenium (Ru), magnesium (Mg), zinc (Zn), platinum (Pt), gold (Au), or the like, and may have a structure including two or more layers such as Ni/Ag, Zn/Ag, Ni/Al, Zn/Al, Pd/Ag, Pd/Al, Ir/Ag. Ir/Au, Pt/Ag, Pt/Al, Ni/Ag/Pt, or the like.

In example embodiments, an upper surface of the ohmic-contact layer **133***b* is provided as a light emitting surface of the light emitting device. In this case, the wavelength conversion layer **140** may be formed on the ohmic-contact layer **133***b*. The wavelength conversion layer **140** may include a light-transmissive resin as a basic material constituting the wavelength conversion layer **140** and nanofibers and a wavelength conversion material dispersed in the light-transmissive resin.

FIG. **12** illustrates a different type light emitting device applied to a semiconductor light emitting device package according to example embodiments. In particular, in case of manufacturing a large light emitting device for a high output, the light emitting device according to example embodiments may be employed as a structure for enhancing current spreading efficiency and heat dissipation efficiency.

As illustrated in FIG. **12**, the light emitting device according to example embodiments may include the first conductivity-type semiconductor layer **131**, the active layer **132**, the second conductivity-type semiconductor layer **133**, a second electrode layer **133***b*, the insulating layer **150**, a first electrode layer **131***a*, and the substrate **120** sequentially laminated. Here, in order to be electrically connected to the first conductivity-type semiconductor layer **131**, the first electrode layer **131***a* includes one or more contact holes H extending from one surface of the first electrode layer **131***a* to at least a partial region of the first conductivity-type semiconductor layer **131** and electrically insulated from the second conductivity-type semiconductor layer **133** and the active layer **132**. However, the first electrode layer **131***a* is not an essential element in example embodiments.

The contact hole H extends from an interface of the first electrode layer **131***a*, passing through the second electrode layer **133***b*, the second conductivity-type semiconductor layer **133**, and the first active layer **132**, to the interior of the first conductivity-type semiconductor layer **131**. The contact hole H extends to at least an interface between the active layer **132** and the first conductivity-type semiconductor layer **131**, and preferably, extends to a portion of the first conductivity-type semiconductor layer **131**. However, the contact hole H is formed for electrical connectivity and current spreading, so the purpose of the presence of the contact hole H is achieved when it is in contact with the first conductivity-type semiconductor layer **131**. Thus, it is not necessary for the contact hole H to extend to an external surface of the first conductivity-type semiconductor layer **131**.

The second electrode layer **133***b* formed on the second conductivity-type semiconductor layer **133** may be selectively made of a material among silver (Ag), nickel (Ni), aluminum (Al), rhodium (Rh), palladium (Pd), iridium (Ir), ruthenium (Ru), magnesium (Mg), zinc (Zn), platinum (Pt), gold (Au), and the like, in consideration of a light reflecting function and an ohmic-contact function with the second conductivity-type semiconductor layer **133**, and may be formed by using a process such as sputtering, deposition, or the like. A second electrode pad **133***a* may be formed on the second electrode layer **133***b*.

The contact hole H may have a form penetrating the second electrode layer **133***b*, the second conductivity-type semiconductor layer **133**, and the active layer **132** so as to be connected to the first conductivity-type semiconductor layer **131**. The contact hole H may be formed through an etching process, e.g., inductively coupled plasma-reactive ion etching (ICP-RIE), or the like.

The insulating layer **150** is formed to cover a side wall of the contact hole H and a surface of the second conductivity-type semiconductor layer **133**. In this case, at least a portion of the first conductivity-type semiconductor layer **131** corresponding to the bottom of the contact hole H may be exposed. The insulating layer **150** may be formed by depositing an insulating material such as SiO_2, SiO_xN_y, or Si_xN_y.

The first electrode layer **131***a* may include a conductive via formed by filling a contact hole H with a conductive material. Subsequently, the substrate **120** is formed on the first electrode layer **131***a*. In this structure, the substrate **120** may be electrically connected to the first conductivity-type semiconductor layer **131** by the conductive via.

The substrate **120** may be made of a material including any one of Au, Ni, Al, Cu, W, Si, Se, GaAs, SiAl, Ge, SiC, AlN, Al_2O_3, GaN, AlGaN and may be formed through a process such as plating, sputtering, deposition, bonding, or the like. But example embodiments are not limited thereto.

In order to reduce contact resistance, the amount, a shape, a pitch, a contact area with the first and second conductivity-type semiconductor layers **131** and **133**, and the like, of the contact hole H may be appropriately regulated. The contact holes H may be arranged to have various shapes in rows and columns to improve current flow. In this case, the conductive via may be surrounded by the insulating layer **150** so as to be electrically separated from the active layer **132** and the second conductivity-type semiconductor layer **133**.

Meanwhile, the wavelength conversion layer **140** may be formed on the first conductivity-type semiconductor layer **131**. The wavelength conversion layer **140** may include a light-transmissive resin as a basic material and nanofibers and a wavelength conversion material dispersed in the light-transmissive resin.

FIG. **13** illustrates a different type light emitting device that may be installed in a semiconductor light emitting device package according to example embodiments. In example embodiments, the light emitting device may be understood as a so-called nano-LED chip type light emitting device.

In detail, as illustrated in FIG. **13**, the light emitting device includes a plurality of nano-light emitting structures **130***n* formed on the substrate **120**. In this example, it is illustrated that the nano-light emitting structure **130***n* has a core-shell structure as a rod structure, but example embodiments are not limited thereto and the nano-light emitting structure **120***n* may have a different structure such as a pyramid structure.

The light emitting device includes a base layer **131'** formed on the substrate **120**. The base layer **131'** is a layer providing a growth surface for the nano-light emitting structure **130***n*, which may be a first conductivity-type semiconductor layer. A mask layer **151** having an open area for the growth of the nano-light emitting structure **130***n* (in particular, the core) may be formed on the base layer **131'**. The mask layer **151** may be made of a dielectric material such as SiO_2 or SiNx.

In the nano-light emitting structure **130***n*, a first conductivity-type nano-core **131** is formed by selectively growing a first conductivity-type semiconductor by using the mask layer **151** having an open area, and the active layer **132** and the second conductivity-type semiconductor layer **133** are formed as shell layers on a surface of the nano-core **131**. Accordingly, the nano-light emitting structure **130***n* may have a core-shell structure in which the first conductivity-type semiconductor is a nano-core and the active layer **132** and the second conductivity-type semiconductor layer **133** enclosing the nano-core are shell layers.

The light emitting device includes a filler material **137** filling spaces between the nano-light emitting structures **130***n* The filler material **137** may structurally stabilize the nano-light emitting structures **130***n*. The filler material **137** may be made of a transparent material such as SiO_2, or the like, but example embodiments are not limited thereto. The ohmic-contact layer **133***b* may be formed on the nano-light emitting structures **130***n* and connected to the second conductivity-type semiconductor layer **133**. The light emitting device includes the base layer **131'** formed of the first conductivity-type semiconductor and first and second electrodes **131***a* and **133***a* connected to the base layer **131'** and the ohmic-contact layer **133***b*, respectively.

By forming the nano-light emitting structures **130***n* such that they have different diameters, components, and doping densities, light beams having two or more different wavelengths may be emitted from the single element. By appropriately adjusting light beams having different wavelengths, white light may be implemented without using phosphors in the single element, and light beams having various desired colors or white light beams having different color temperatures may be implemented by combining a different LED chip to the foregoing element or combining wavelength conversion materials such as phosphors.

In the case of the light emitting device using the nano-light emitting structure **130***n*, since a light emitting area is increased by utilizing the nano-structure, luminous efficiency can be enhanced, and since a non-polar active layer is obtained, a degradation of efficiency due to polarization can be limited (and/or prevented), improving drop characteristics. In particular, since recombination density of non-radiative recombination is low, a relatively small amount of heat is generated, effectively improving mismatch in coefficients of thermal expansion.

Also, the wavelength conversion layer **140** may be formed on the ohmic-contact layer **133***b*. In order to limit (and/or prevent) damage to the wavelength conversion layer due to mismatch in coefficients of thermal expansion, the wavelength conversion layer **140** may include a light-transmissive resin as a basic material thereof and nanofibers and a wavelength conversion material dispersed in the light-transmissive resin.

Meanwhile, besides the foregoing light emitting devices, light emitting devices having various other structures may also be employed in a light emitting device package according to example embodiments. For example, a light emitting device in which surface-plasmon polaritons (SPP) are formed in a metal-dielectric boundary to interact with quantum well excitons, thus obtaining significantly improved light extraction efficiency, may also be advantageously used.

FIG. **14** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments. Example embodiments may be understood as being implemented as a chip scale package (CSP).

In detail, referring to FIG. **14**, the light emitting device according to example embodiments includes the light emitting laminate **130** and the wavelength conversion layer **140**, and the light emitting device package according to example embodiments includes the package body **210** including the first and second electrode structures **221** and **222**, and the light emitting device and a lens **400** disposed on the package body **210**.

The light emitting laminate **130** has a lamination structure including the first and second conductivity-type semiconductor layers **131** and **133** and the active layer **132** disposed therebetween. In example embodiments, the first and second conductivity-type semiconductor layers **131** and **133** may be p-type and n-type semiconductor layers, respectively, and may be made of a nitride semiconductor, e.g., $Al_xIn_yGa_{(1-x-y)}N$ ($0 \le x \le 1$, $0 \le y \le 1$, $0 \le x+y \le 1$). However, besides a nitride semiconductor, a GaAs-based semiconductor or GaP-based semiconductor may also be used.

The active layer **132** formed between the first and second conductivity-type semiconductor layers **131** and **133** may emit light having a desired (or alternatively predetermined) level of energy according to electron-hole recombination, and may have a multi-quantum well (MQW) structure in which a quantum well layer and a quantum barrier layer are alternately laminated. In the case of the MQW structure, for example, an InGaN/GaN or AlGaN/GaN structure may be used.

Meanwhile, the first and second conductivity-type semiconductor layers **131** and **133** and the active layer **132** may be formed by using a semiconductor growth process such as metal-organic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE), hydride vapor phase epitaxy (HVPE), or the like.

The light emitting device illustrated in FIG. **14** is in a state in which a growth substrate was removed, and depressions and protrusions P may be formed on the surface from which the growth substrate was removed. Also, the wavelength conversion layer **140** may be applied to the uneven surface, as a light conversion layer. Here, the wavelength conversion layer **140** may include a light-transmissive resin as a basic material and a wavelength conversion material dispersed therein.

The light emitting device includes the first and second electrodes **131***a* and **133***a* connected to the first and second conductivity-type semiconductor layers **131** and **133**, respectively. The first electrode **131***a* may have a conductive via C**3** connected to the first conductivity-type semiconductor layer **131** through the second conductivity-type semiconductor layer **133** and the active layer **132**. The insulating layer **150** is formed between the active layer **132** and the second conductivity-type semiconductor layer **133** in the conductive via C**3** to limit (and/or prevent) a short-circuit occurrence.

A single conductive via C**3** is illustrated, but two or more conductive vias C**3** may be provided to advantageously distribute current, and may be arranged in various forms.

The package body **210** employed in this example may include a resin as a basic material thereof, and include nanofibers and light-reflective powder particles dispersed in the resin. Here, the package body **210** and the light emitting device may be bonded by bonding layers B**1** and B**2**. The bonding layers B**1** and B**2** may be made of an electrically insulating material or an electrically conductive material. For example, the electrically insulating material may include an oxide such as SiO_2, SiN, or the like, a resin material such as a silicone resin, an epoxy resin, or the like. The electrically conductive material may include silver (Ag), aluminum (Al), titanium (Ti), tungsten (W), copper (Cu), tin (Sn), nickel (Ni), platinum (Pt), chromium (Cr), NiSn, TiW, AuSn, or a eutectic metal alloy thereof. This process may be implemented such that the first and second bonding layers B**1** and B**2** are applied to respective bonding surfaces of the package body **210** and the package body **210** and the light emitting device and subsequently bonded.

A contact hole is formed from a lower surface of the package body **210** so as to be connected to the first and second electrodes **131***a* and **133***a* of the light emitting device as bonded. The insulating layer **150** may be formed on a lateral surface of the contact hole and on a lower surface of the package body. In a case in which the package body **210** is a silicon substrate, the insulating layer **150** may be provided as a silicon oxide film through thermal oxidation. The contact hole is filled with a conductive material to form the first and second electrodes **221** and **222** such that they are connected to the first and second electrodes **131***a* and **133***a*. The first and second electrode structures **221** and **222** may include seed layers S**1** and S**2** and plating charged units **221***c* and **222***c* formed through a plating process by using the seed layers S**1** and S**2**.

The chip-scale package (CSP) as described above and as illustrated in FIG. **14**, reducing a size of the light emitting device package and simplifying a manufacturing process, is appropriate for mass-production, and since the light emitting device including the wavelength conversion layer according to example embodiments and the optical structure such as the lens can be integrally manufactured, the CSP can be appropriately employed in a light emitting apparatus, or the like.

Meanwhile, in example embodiments, matching of coefficients of thermal expansion as major characteristics of a material constituting the package body and the wavelength conversion layer has been largely described, but the package body and the wavelength conversion layer according to example embodiments can have remarkably improved tensile strength, in comparison to a case in which only a resin is employed as a basic material.

FIG. **15** is a graph showing characteristics of a package body and a wavelength conversion layer according to example embodiments. In detail, (i) is a stress-strain curve when nanofibers are contained in the amount of 0.1% to 5% in a resin, and (ii) is a stress-strain curve of a resin not containing nanofibers. For the curves (i) and (ii), an acrylic resin was used.

Referring to FIG. **15**, it can be seen that in the case (i) in which nanofibers are dispersed in a resin, stress to be applied to generate the same strain is significantly increased, in comparison to the case (ii) in which only the resin is employed as a basic material.

Namely, in the light emitting device package according to example embodiments, a difference in coefficients of thermal expansion between the light electrode structure, the light emitting device, and the package body is significantly reduced and tensile strength of the package body is increased, and thus, defects due to deformation of the package body due to differences in coefficients of thermal expansion can be effectively improved.

In addition, in the light emitting device according to example embodiments, a difference in coefficients of thermal expansion in the surfaces of contact between the light emitting laminate and the wavelength conversion layer is significantly reduced and tensile strength of the wavelength conversion layer is increased, and thus, a degradation of optical properties due to deformation of the wavelength conversion layer can be improved.

FIG. **16** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments.

Referring to FIG. **16**, according to example embodiments, a light emitting device and a light emitting device package may be the same as the light emitting device and light emitting device page described previously in FIG. **1**, except for the structure of the package body **210'** and the wavelength conversion layer **140"** compared to the package body **210** and wavelength conversion layer **140** in FIG. **1**. As shown in region C of FIG. **16**, the package body **210'** may include a resin as a basic material and nanofibers **20** with light-reflective powder particles **31** adhered to the nanofibers **20**. As shown in region D of FIG. **16**, the wavelength conversion layer **140"** may include a light-transmissive resin **11** as a basic material with wavelength conversion material **32** adhered to nanofibers **20** dispersed in the light-transmissive resin **11**.

FIG. **17** is a cross-sectional view of a light emitting device and a light emitting device package according to example embodiments.

Referring to FIG. **17**, according to example embodiments, a light emitting device and a light emitting device package may be the same as the light emitting device and light emitting device page described previously in FIG. **1**, except for the structure of the wavelength conversion layer **140'''** compared to the wavelength conversion layer **140** in FIG. **1**. As shown in region E of FIG. **17**, the wavelength conversion layer **140'** may include a light-transmissive resin **11** as a basic material with wavelength conversion material **32** and nanofibers **20** dispersed in the light-transmissive resin **11**. Unlike the wavelength conversion layer **140** in FIG. **1**, the wavelength conversion layer **140'''** in FIG. **17** may be spaced apart from the light emitting laminate **130**. For example, the wavelength conversion layer **140'''** in FIG. **17** may be on an upper surface of the encapsulation unit **300**.

As set forth above, according to example embodiments, a light emitting device package in which a defect due to a difference between coefficients of thermal expansion is improved can be obtained.

According to example embodiments, a light emitting device having a wavelength conversion unit, in which a degradation of optical quality is improved, can be obtained.

While some example embodiments have been particularly shown and described, it will be understood by one of ordinary skill in the art that variations in form and detail may be made therein without departing from the spirit and scope of the claims.

What is claimed is:

1. A light emitting device package comprising:

a package body including nanofibers and light-reflective particles dispersed in a resin;

first and second electrodes in the package body; and

a light emitting device on the package body,

the light emitting device being electrically connected to the first and second electrodes.

2. The light emitting device package of claim **1**, wherein the resin includes one of epoxy, silicone, modified silicone, a urethane resin, an oxetane resin, acryl, polycarbonate, polyimide, and any combination thereof.

3. The light emitting device package of claim **1**, wherein the nanofibers include at least one of chitin and cellulose.

4. The light emitting device package of claim **1**, wherein a width of the nanofibers is equal to or less than about 80 nm.

5. The light emitting device package of claim **1**, wherein a length of the nanofibers is equal to or greater than about 1 μm.

6. The light emitting device package of claim **1**, wherein a weight ratio of the nanofibers to the resin ranges from 1% to about 5%.

7. The light emitting device package of claim **1**, wherein a coefficient of thermal expansion of the package body ranges from about 4 ppm/K to 10 ppm/K at a temperature ranging from about 20° C. to about 150° C.

8. The light emitting device package of claim **1**, wherein a weight ratio of the light-reflective particles to the resin ranges from about 20% to about 80%.

9. A light emitting device comprising:

a light emitting laminate including a first conductivity-type semiconductor layer, an active layer, and a second conductivity-type semiconductor layer stacked on each other,

the active layer between the first and second conductive-type semiconductor layers; and

a wavelength conversion layer on the light emitting laminate,

the wavelength conversion layer including nanofibers and a wavelength conversion material dispersed in a light-transmissive resin,

wherein the nanofibers include at least one of chitin and cellulose.

10. The light emitting device of claim **9**, wherein a weight ratio of the nanofibers to the resin ranges from 0.1% to less than 1%.

11. The light emitting device of claim **9**, wherein one surface of the wavelength conversion layer contacts the light emitting laminate.

12. The light emitting device of claim **9**, wherein the wavelength conversion layer directly contacts a light emitting surface of the light emitting laminate.

13. The light emitting device of claim **9**, wherein a thickness of the wavelength conversion layer ranges from about 20 μm to about 200 μm.

14. The light emitting device of claim **9**, wherein a weight ratio of the wavelength conversion material to the resin ranges from about 50% to about 300%.

15. A light emitting device comprising:

a light emitting laminate; and

a wavelength conversion layer on the light emitting laminate,

the wavelength conversion layer including nanofibers and a wavelength conversion material dispersed in a light-transmissive resin,

wherein a width of the nanofibers is less than or equal to 80 nm.

16. The light emitting device of claim **15**, wherein at least some of the nanofibers are spaced apart from at least some of the wavelength conversion material.

17. The light emitting device of claim **15**, wherein

the nanofibers include at least one of chitin and cellulose.

18. A light emitting device package comprising:

a package body including fibers and light-reflective particles dispersed in a resin material; and

the light-emitting device of claim **15** on the package body.

19. The light emitting device package of claim **18**, wherein the fibers include at least one of chitin and cellulose, and a width of the fibers is less than or equal to 80 nm.

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